

Can Physical Activity Minimize Weight Gain in Women after Smoking Cessation?

ABSTRACT

Objectives. The purpose of this study was to examine prospectively whether exercise can modify weight gain after smoking cessation in women.

Methods. Data were analyzed from a 2-year follow-up period (1986-1988) in the Nurses' Health Study, an ongoing cohort of 121 700 U.S. women aged 30 to 55 in 1986.

Results. The average weight gain over 2 years was 3.1 kg in the 1474 women who stopped smoking, and 0.6 kg among the 7832 women who continued smoking. Among women smoking 1 to 24 cigarettes per day, those who quit without changing their levels of exercise gained an average of 2.3 kg more (95% confidence interval [CI] = 1.9, 2.6) than women who continued smoking. Women who quit and increased exercise by between 8 to 16 MET-hours (the work metabolic rate divided by the resting metabolic rate) per week gained 1.8 kg (95% CI = 1.0, 2.6), and the excess weight gain was only 1.3 kg (95% CI = 0.7, 1.9) in women who increased exercise by more than 16 MET-hours per week.

Conclusions. Smoking cessation is associated with a net excess weight gain of about 2.4 kg in middle-aged women. However, this weight gain is minimized if smoking cessation is accompanied by a moderate increase in the level of physical activity. *Am J Public Health*. 1996;86:999-1004.

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Introduction

Weight gain is a well-established concomitant of smoking cessation,¹ and has been cited as a factor that may inhibit cessation attempts among smokers.^{2,3} Concern about weight gain is said to be an especially prominent barrier for women attempting to quit smoking,⁴⁻⁶ although empirical studies have yielded inconsistent findings.⁷ For example, some investigators have reported that weight gain during early abstinence actually predicted long-term abstinence, not relapse.⁸⁻¹⁰

The causes of weight gain after smoking cessation have not been completely elucidated.⁷ Among the likely explanations are that nicotine acutely increases metabolic rate,¹¹⁻¹³ whereas smoking cessation is often accompanied by a transient increase in caloric intake.¹⁴⁻¹⁸ In clinical trials, attempts to suppress postcessation weight gain have been generally unsuccessful,^{19,20} leading at least some investigators to conclude that, instead of developing intensive interventions to prevent weight gain, a more prudent strategy might be to help smokers to accept this relatively small weight gain.^{7,21}

It may be premature, however, to give up altogether efforts to minimize postcessation weight gain, because very few population-based observational studies have actually evaluated the impact of modifiable behaviors such as exercise on weight gain among quitters. In this study, we examined prospectively in a large cohort of women whether changes in exercise accompanying smoking cessation could modify postcessation weight gain.

Methods

The Nurses' Health Study Cohort

The Nurses' Health Study cohort was established in 1976, when 121 700 female

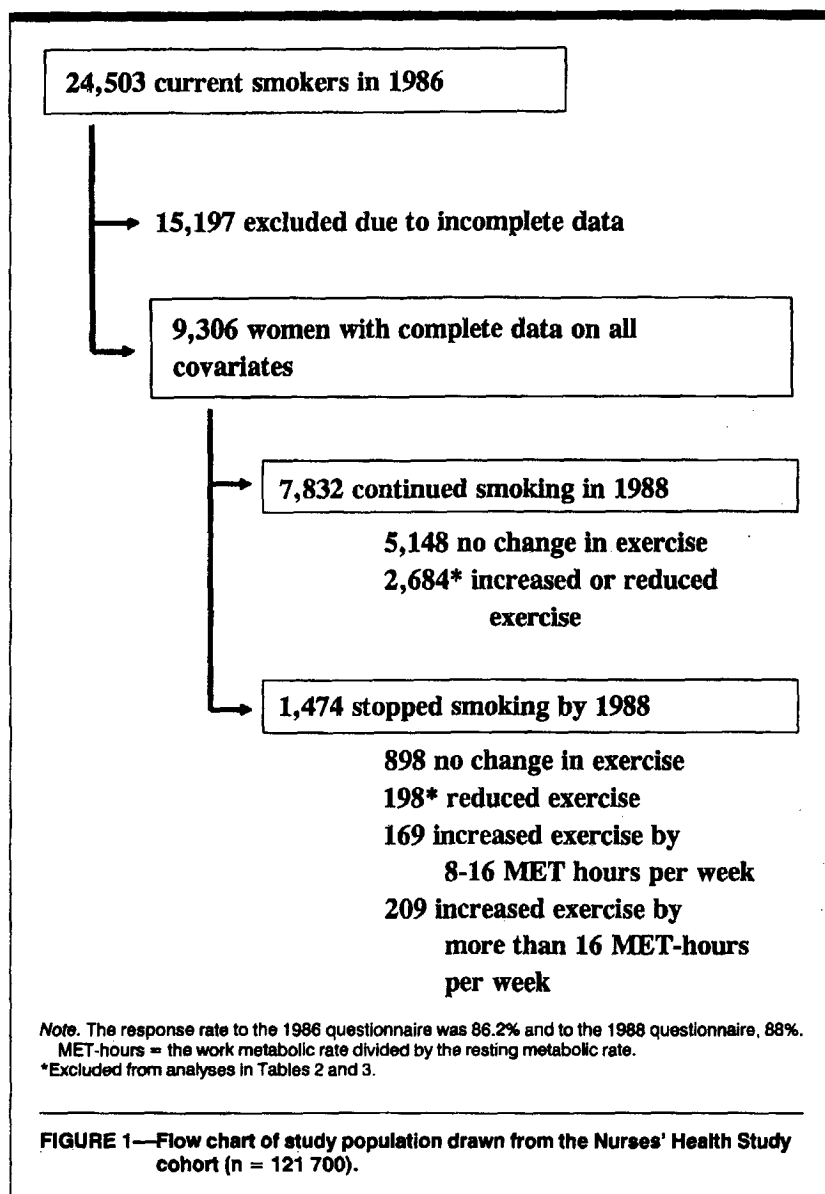
registered nurses 30 to 55 years of age completed a mailed questionnaire requesting information about risk factors for cancer and coronary heart disease, including current and past smoking habits, height, weight, and past personal history of diabetes, hypertension, and high serum cholesterol levels. Since 1976, follow-up questionnaires have been mailed every 2 years to the entire cohort to update information on smoking behavior, other cardiovascular risk factors, and the diagnosis of major illness. Further details of the Nurses' Health Study have been presented elsewhere.^{22,23}

Women in the cohort were categorized as never, current, or former smokers according to their smoking status as reported on the biennial follow-up questionnaires. Current smokers were further classified as using 1 to 4, 5 to 14, 15 to 24, 25 to 34, 35 to 44, or 45 or more cigarettes per day. Women were considered to have stopped smoking if they reported themselves as current smokers in 1986 and former smokers in 1988. The validity of self-reported smoking status in observa-

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tional studies has been confirmed in numerous reports by using biochemical markers (such as salivary cotinine and carboxyhemoglobin) as the gold standard.¹

Assessment of Self-Reported Weight and Other Health Behaviors

The validity of self-reported weight in this cohort was established in a sub-study of 184 participants living in the greater Boston area.^{24,25} Six to 12 months after completing the study questionnaire, participants were weighed in light clothing on a digital bathroom scale. The correlation between self-reported and directly measured weight was 0.96. Although women tended to underestimate their weight by about 1.5 kg, this tendency

did not differ according to body mass index.²⁵

Beginning in 1986, we assessed levels of regular physical activity, using a highly reproducible, validated questionnaire that assesses the frequency of eight common activities that women engage in.²⁶ The physical activity questionnaire enabled us to calculate a total activity score, measured in MET-hours per week, for each participant during the past year. One MET-hour is the metabolic equivalent of resting for 1 hour. For example, walking at an average pace for 1 hour is estimated to consume about 3.0 MET-hours or units; the MET units for calisthenics and for jogging or bicycling are about 6.0 and 7.0 per hour, respectively.²⁷

In 1980 a dietary component, in the form of a semiquantitative food frequency questionnaire, was added to the study. The validity and reproducibility of this food frequency questionnaire were reported elsewhere.^{28,29} Briefly, the food frequency questionnaire asks about usual dietary intake over the past year by listing food items with serving sizes and nine response categories for frequency of intake. The food frequency questionnaire enabled us to estimate the total caloric intake (in kilocalories per day), energy-adjusted alcohol intake (in grams of ethanol per day), and energy-adjusted fat intake (in grams per day) of each participant.

The Study Population

We excluded women at baseline (in 1986) who had a diagnosed history of angina, myocardial infarction, stroke, diabetes, or cancer (excluding nonmelanoma skin cancer). We also excluded women who reported being pregnant during the period 1984 through 1986 and women who reported extreme levels of exercise (defined as more than 20 hours per week) (n = 98). After these exclusions were made, there were 24 503 current smokers in the cohort in 1986, aged 40 to 70 years (Figure 1).

We then excluded from analysis 15 197 women for whom we lacked complete information on all the covariates of interest: body weight; smoking status; physical activity in 1986, 1988, or both years; age; intake of total calories, fat, and alcohol in 1986; and personal history of hypertension and hypercholesterolemia. The main reason for exclusion at this stage was missing information on weight (n = 12 996 for whom weight was missing in 1986, 1988, or both years).

Thus, we had complete data on all the covariates of interest for 9306 women. We assessed the extent of bias caused by the missing data by comparing the outcome (mean self-reported weight in 1988) among the 9306 women with complete data to the outcome among a subgroup of 4496 women who were excluded from analysis due to one or more missing covariates, but for whom self-reported weight was available in 1988. The mean self-reported weights in the two groups were 66.4 kg and 67.0 kg, respectively. Similarly, when we compared mean baseline weights (in 1986), we found little difference between the group with complete data (mean = 65.4 kg) and the subgroup of 2699 women who reported their weight in 1986 (mean = 66.0 kg) but

TABLE 1—Mean Values for Health Behaviors and Risk Factors in Sample, by Change in Smoking Status and Change in Level of Physical Activity between 1986 and 1988

Risk Factor	Mean (95% CI)			
	Continue Smoking with No Change in Exercise	Quit Smoking with No Change in Exercise	Quit Smoking with Increase of 8–16 MET-Hrs/wk	Quit Smoking with Increase of > 16 MET-Hrs/wk
No. subjects	5148	898	169	209
Age in 1986, y	51.7 (51.5, 51.9)	52.2 (51.8, 52.7)	52.6 (51.5, 53.6)	51.7 (50.8, 52.7)
Weight in 1986, kg	65.6 (65.3, 66.0)	67.3 (66.5, 68.1)	64.5 (62.9, 66.1)	64.1 (62.5, 65.7)
Weight in 1988, kg	66.3 (66.0, 66.7)	70.6 (69.7, 71.4)	67.1 (65.4, 68.9)	66.3 (64.8, 67.9)
Change in weight in 1984–1986, kg	0.6 (0.5, 0.7)	0.8 (0.5, 1.0)	1.3 (0.8, 1.8)	0.6 (0.2, 1.0)
Percentage of heavy (≥ 25 cigarettes/day) smokers	31.9 (30.6, 33.1)	18.8 (16.3, 21.4)	19.5 (13.6, 25.5)	17.2 (12.1, 22.3)
Physical activity in 1986, MET-hours/week	6.0 (5.8, 6.2)	7.6 (6.9, 8.3)	7.7 (6.3, 9.0)	11.0 (9.2, 12.7)
Physical activity in 1988, MET-hours/week	6.1 (5.9, 6.4)	7.8 (7.2, 8.5)	18.6 (17.1, 20.1)	41.5 (38.8, 44.1)
Change in physical activity in 1986–1988, MET-hours/week	0.1 (0.0, 0.2)	0.2 (0.0, 0.5)	11.0 (10.6, 11.3)	30.6 (28.7, 32.5)
Total caloric intake in 1986, kcal/day	1730 (1720, 1750)	1710 (1670, 1740)	1760 (1690, 1830)	1770 (1690, 1850)
Energy-adjusted alcohol intake in 1986, g/day	9.2 (8.8, 9.6)	7.7 (6.9, 8.5)	8.1 (6.3, 9.8)	7.4 (6.0, 8.8)
Energy-adjusted total fat intake in 1986, g/day	60.1 (59.8, 60.4)	59.1 (58.4, 59.8)	59.5 (57.8, 61.1)	59.0 (57.6, 60.3)
Hypertension prevalence in 1986, %	11.9 (11.1, 12.8)	12.7 (10.5, 14.9)	15.4 (9.9, 20.8)	10.5 (6.4, 14.7)
Hypercholesterolemia prevalence in 1986, %	5.9 (5.2, 6.5)	6.0 (4.5, 7.6)	7.7 (3.7, 11.7)	6.7 (3.3, 10.1)

Note. MET-hours = the work metabolic rate divided by the resting metabolic rate; CI = confidence interval.

who were excluded because of missing weight data in 1988. We therefore concluded that major systematic bias was unlikely to have been introduced by the exclusion of women with missing data.

We analyzed the study population in two ways. First, in analyses comparing the overall effect of quitting smoking relative to continued smoking, we used the entire population of 9306 women for whom we had complete data. In the second set of analyses, where we examined the effects of physical activity on postcessation weight gain, we used data only from women in the following four mutually exclusive groups, as defined by their postcessation levels of exercise: women who stopped smoking and increased their level of physical activity by between 8 and 16 MET-hours per week (equivalent to 1–2 hours of vigorous activity per week); women who stopped smoking and increased their level of activity by more than 16 MET-hours per week (equivalent to 2 or more hours of vigorous exercise per week); women who stopped smoking and maintained their precessation levels of activity (within ± 7 MET-hours per week); and women who continued smoking and maintained a constant level of physical activity (within ± 7 MET-hours per week) (Figure 1). In this set of analyses, we therefore did not include the women who quit smoking and reduced their level of physical activity ($n = 198$) or the women who continued smoking and changed

their level of exercise (Total = 2684, of whom 1038 reduced their level of exercise and 1646 increased their level of exercise). Thus, a total of 2882 (198 + 2684) women were excluded from our multivariate analyses because they did not contribute information to our primary hypothesis: that postcessation exercise minimizes weight gain.

The cut point of 8 to 16 MET-hours per week to define change in physical activity was chosen a priori to represent a realistic and plausible change in lifestyle after smoking cessation. For example, this level of physical activity could be achieved by engaging in aerobics for half an hour three to four times per week.

The years 1986 to 1988 were chosen for analysis because of the availability of simultaneous dietary and physical activity assessments from cohort members during this period. The 2-year follow-up period was chosen because the majority of postcessation weight gain in fact occurs within 2 years of quitting.^{1,7} It should be pointed out that the women in the study could have stopped smoking or changed their physical activity at any time during the 2-year follow-up period. Thus, quitters in 1988 may have included subjects who had stopped a few days before completing the 1988 survey. Information was not available on the length of time since quitting within the 2-year study period.

Data Analysis

We first examined the overall effect of stopping smoking on weight change. We stratified mean weight change (from 1986 to 1988) according to whether subjects quit or continued to smoke, without adjusting for possible confounding variables. We examined also the predictors of smoking cessation, including age, baseline weight, and intensity of smoking. These analyses used the entire study population ($n = 9306$; Figure 1).

In our analyses examining the impact of physical activity on postcessation weight gain, we used multiple linear regression analyses³⁰ to adjust for a wide range of potential confounding factors. Our outcome variable was change in weight (in kilograms) between 1986 and 1988. For our predictor variables, we created dummy variables to describe the three alternative strategies available to women on stopping smoking: no change in physical activity, increase in exercise between 8 and 16 MET-hours per week, and increase in exercise of more than 16 MET-hours per week. The reference category consisted of the women who continued to smoke without altering their levels of physical activity. Because our primary hypothesis concerned the benefit of increased exercise among women who stop smoking, we excluded from these analyses the 198 women who cut down on exercise after quitting, as well as the 2684 women who

TABLE 2—Unadjusted Comparison of Average Weight Increase from 1986 to 1988 among Groups Defined by Change in Smoking Status and in Level of Physical Activity, by Amount of Smoking in 1986

Group	No. Subjects	Weight Gain, kg (No. Subjects)		
		1–24 Cig/Day in 1986	≥ 25 Cig/Day in 1986	All Subjects
Continue smoking with no change in exercise	5148	0.6 (3507)	0.8 (1641)	0.7 (5148)
Quit smoking with no change in exercise	898	2.8 (729)	5.4 (169)	3.2 (898)
Quit smoking with increase in exercise of 8–16 MET-hours per week	169	2.1 (136)	4.6 (33)	2.6 (169)
Quit smoking with increase in exercise of > 16 MET-hours per week	209	2.0 (173)	3.5 (36)	2.2 (209)

Note. MET-hours = the work metabolic rate divided by the resting metabolic rate.

TABLE 3—Adjusted* Increase in Weight from 1986 to 1988 among Women Who Stopped Smoking, by Level of Smoking in 1986 and Change in Physical Activity between 1986 and 1988

Change in Physical Activity from 1986 to 1988	No. Subjects	Weight Gain, kg (95% CI)	
		1–24 Cig/Day in 1986	≥ 25 Cig/Day in 1986
No change	898	2.3 (1.9, 2.6)	4.5 (3.9, 5.2)
Increase by 8–16 MET-hrs/wk	169	1.8 (1.0, 2.5)	3.9 (2.5, 5.3)
Increase by > 16 MET-hrs/wk	209	1.3 (0.7, 1.9)	2.9 (1.5, 4.3)

Note. MET-hours = the work metabolic rate divided by the resting metabolic rate; CI = confidence interval.

*Adjusted for age, height, baseline weight (in 1986), weight change during the period before baseline (1984–1986), baseline total caloric intake, energy-adjusted baseline fat and alcohol intake, and personal history of hypertension or high serum cholesterol. The reference group in the regression model consisted of 5148 women who continued to smoke through 1988 and who reported no change (± 7 MET-hours per week) in level of physical activity.

continued smoking but changed their exercise habits (Figure 1).

All regression models included terms for daily amounts of cigarettes smoked in 1986 (1–24 vs 25 or more), as well as an interaction term between smoking amount and exercise patterns after quitting. We entered the following confounding variables in our multivariate models: baseline weight (in 1986), weight change (kilograms) in the period before baseline (1984–1986), height in 1976, age in 1986, total caloric intake (in kilocalories per day) in 1986, energy-adjusted alcohol intake and fat intake in 1986, total physical activity score (in MET-hours per week) in 1986, and indicator variables for personal history of high blood pressure and high serum cholesterol.

Results

The Overall Effect of Smoking Cessation on Weight Gain

Of 9306 current smokers in 1986, 1474 (15.8%) stopped smoking during the 2-year follow-up period to 1988 (Figure 1). The daily amount of smoking was the strongest predictor of quitting. Eighty-two percent ($n = 1213$) of the women who quit in 1988 were light smokers (1–24 cigarettes per day), compared with 69.7% ($n = 5461$) among continuing smokers (crude odds ratio of quitting among light smokers = 2.0; 95% confidence interval [CI] = 1.8, 2.3). Neither age nor baseline weight was a statistically significant predictor of smoking cessation.

Overall, women who stopped smoking gained an average of 3.0 kg during the subsequent 2-year period, compared with an average weight gain of 0.6 kg among women who continued smoking; in other words, there was an excess 2.4-kg weight gain associated with smoking cessation.

The Effect of Physical Activity on Postcessation Weight Gain

Results presented in this section compare the weight gain among defined groups of quitters (no change in exercise, $n = 898$; increase exercise by 8–16 MET-hours per week, $n = 169$; increase exercise by more than 16 MET-hours, $n = 209$) with the weight gain among the women who continued smoking without altering their exercise habits ($n = 5148$). We first compared the distributions of health habits and risk factors in these four mutually exclusive groups of women (Table 1). Compared with women who stopped smoking, continuing smokers reported higher levels of alcohol intake and were more likely to be heavier smokers (using 25 or more cigarettes per day) at baseline in 1986. Women who quit smoking and increased their exercise levels by more than 16 MET-hours per week also reported higher levels of physical activity at baseline (mean = 11 MET-hours per week) compared with other groups. We adjusted for these potential confounding variables in multivariate regression models described below.

Before carrying out multivariate analyses, we examined the unadjusted mean weight gains in the four groups of women, stratified by level of cigarette smoking (Table 2). The average weight gains in women who continued smoking without changing their level of physical activity ranged from 0.6 kg among light smokers (1–24 cigarettes per day) to 0.8 kg among heavy smokers (25 or more cigarettes per day). By comparison, the average weight gains in women who quit smoking without changing their physical activity patterns ranged from 2.8 kg among light smokers to 5.4 kg among heavy smokers. Increasing the level of physical activity at the same time as stopping smoking mitigated the extent of weight gain.

One hundred and ninety-eight women quit smoking and decreased their level of physical activity between 1986 and 1988. The average weight gain in this group (3.0 kg) was similar to that observed in the group of women who quit smoking without changing their level of physical activity (data not shown in Table 2).

Among women who continued smoking, 1038 decreased their exercise levels and gained an average of 0.7 kg from 1986 to 1988, and 1646 increased their exercise levels and gained an average of 0.2 kg during the 2-year follow-up period (data not shown in Table 2). Because these groups of women did not contribute information to our primary hypothesis (that postcessation exercise minimizes weight gain), we did not consider them further in our analyses.

We next performed multiple linear regression analyses, adjusting for potential confounding factors including age, height, baseline weight (in 1986), weight change during the period before baseline (1984–1986), baseline total caloric intake, energy-adjusted baseline fat and alcohol intake, and personal history of hypertension or high serum cholesterol. Table 3 shows the predicted excess weight gains (in kilograms) among women who stopped smoking, stratified by change in level of physical activity from 1986 to 1988 as well as by daily amounts smoked (1–24 vs 25 or more cigarettes per day). The reference group for this analysis was the 5148 women who continued smoking through 1988 and who did not alter their patterns of physical activity. All values shown are for a hypothetical woman with the same average characteristics as the cohort (i.e., 52 years of age, height equal to 1.6 m, total daily caloric intake of 1740 kcal, and so on).

Relative to women who continued smoking, the women who gained the most weight were those who quit without adjusting their level of physical activity. However, the excess weight gains were much less if smoking cessation was accompanied by increased physical activity. A light smoker (1–24 cigarettes per day) was predicted to gain only 1.3 kg more than a continuing smoker over a 2-year period if smoking cessation was accompanied by an exercise program equivalent to about 45 extra minutes of walking per day.

Neither baseline total caloric intake nor energy-adjusted fat intake predicted baseline weight or weight change in our models. When we repeated our regression models without these dietary variables, the remaining coefficients were virtually unchanged. There was a statistically significant inverse effect of alcohol consumption at baseline on subsequent weight gain; however, the effect size was small—less than one-hundredth the effect of our key predictor variables. Other statistically significant predictors of weight change included age (the older the subject, the less the weight change), weight in 1986 (the

heavier the baseline weight, the greater the weight gain), and baseline physical activity level (the higher the level of exercise, the lower the weight gain).

Discussion

Concern about weight gain is a frequently cited barrier to women's attempts to quit smoking,^{4–6} yet few population-based studies have examined whether this weight gain can be modified by other behavioral changes accompanying smoking cessation such as increased exercise or dietary modification.² The present study suggests that moderate increases in physical activity can minimize postcessation weight gain in women.

Hall et al.¹⁹ conducted a small intervention trial that included an individualized exercise plan as one of the components of a strategy to prevent postcessation weight gain. Preliminary findings from the trial failed to find any effect of the intervention on minimizing weight gain. Moreover, quitters randomized to active intervention (which included the exercise program) appeared to have a higher relapse rate than the control group.¹⁹ It was not clear from the study, however, whether the exercise component of the intervention was responsible for its failure. The authors attributed their unexpected finding to the overall complexity of their intervention, which included not only the exercise regimen, but also a caloric restriction component and behavior modification.¹⁹ In particular, caloric restriction in the context of smoking cessation may have actually increased the reinforcing value of a psychoactive substance such as nicotine.¹⁹

Recent data suggest that exercise training may help to improve long-term maintenance of smoking cessation in women.^{31,32} Further intervention trials are thus warranted to confirm our finding that physical activity minimizes postcessation weight gain.

A limitation of our study is that we did not collect data on the average length of time since quitting within the 2-year study interval. Thus, quitters in our study may have included women who stopped smoking just a few days before completion of the 1988 questionnaire. If the groups reporting various exercise levels differed in their length of time since quitting, then the latter variable could have acted as a confounder in the relationship between exercise levels and weight gain. For example, if recent quitters exercise more heavily than longer-term quitters, then

exercise might appear to be spuriously associated with less weight gain. In fact, longer duration of abstinence tends to be associated with higher levels of physical activity in this cohort. However, this relationship may not necessarily hold among the most recent (less than 2 years) quitters.

A further limitation of our study is that no information was obtained on nicotine replacement therapy that may have accompanied smoking cessation. Several studies have documented an acute effect of nicotine on raising the metabolic rate. In a study of 18 male smokers, Perkins et al.¹¹ reported a statistically significant increase in metabolic rate that was 6% above baseline values after a measured dose of nicotine via nasal spray, compared with a 3% increase after placebo administration. Several studies also found attenuated weight gain after smoking cessation in individuals receiving nicotine replacement therapy.^{33,34} In a 6-month follow-up study of 28 patients discharged from a smoking-cessation clinic, frequent users of gum (> 263 pieces of gum over 6 months) gained an average of 0.9 kg; less frequent users of gum (< 263 pieces) gained an average of 3.1 kg.³⁴ However, others have shown that individuals gain significant amounts of weight after being weaned off nicotine replacement therapy, so that nicotine gum may act more to delay, rather than prevent, weight gain.³³

Some studies reported increases in sugar intake,^{17,35} fat intake,¹⁷ and total caloric intake¹⁸ after smoking cessation. In a careful assessment of changes in energy balance after smoking cessation, Stamford and colleagues¹⁸ reported that mean daily caloric intake increased by 227 kcal among 13 sedentary women who quit smoking for a 48-day period. No change in physical activity occurred. The increase in caloric consumption accounted for 69% of the average 4.85-lb weight gain found after cessation. In the present study, we were unable to examine the effects of postcessation caloric intake. Without follow-up dietary data, we recognize the difficulty in attributing postcessation weight change to exercise alone. On the other hand, caloric intake at baseline had no relation to weight in 1988 ($\beta = 0.000$, $P = .81$), whereas the physical activity, measured in MET-hours, did ($\beta = -0.014$, $P = .0001$). Moreover, most studies suggest that increased caloric intake after smoking cessation is transient and is not sustained beyond several weeks or months.⁷ In particular, cross-sectional studies have found no evidence of re-

duced eating in smokers compared with never smokers or former smokers.⁷

Conclusion

In summary, women who stop smoking gain between 1 and 4.5 kg more weight over a 2-year period, depending on their precessation levels of smoking and postcessation exercise patterns, compared with continuing smokers. The 1990 Surgeon General's report concluded that the benefits of giving up smoking far outweigh the risks associated with the typical level of postcessation weight gain.¹ Our own 12-year follow-up study of smoking cessation in the Nurses' Health Study³⁶ supports this conclusion. That analysis, which was based on changes in total mortality rates after stopping smoking, reflected the balance between any adverse and desirable effects of smoking cessation. Within 2 years of stopping smoking, total mortality rates for former smokers dropped by 17% compared with those for continuing smokers. Thus, when smokers mention weight gain as the major barrier to giving up cigarettes, their concern is targeted more on the effects of weight gain on personal appearance than on health. Public health efforts should continue to vigorously oppose tobacco industry advertisements that associate cigarette smoking with slimness.³⁷ Meanwhile, these data support the notion that weight gain after smoking cessation can be minimized by even modest amounts of exercise. □

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